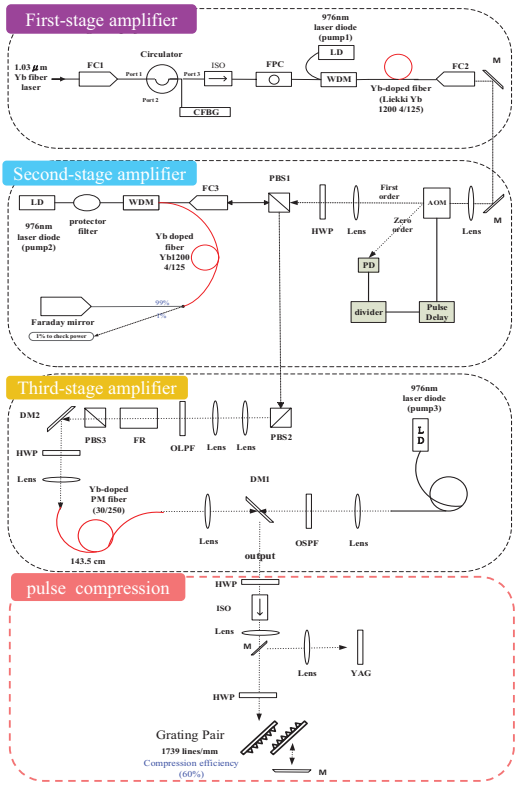
Yb-doped double-cladding fiber chirped-pulsed amplifier pulse compression

Kai-Yu Lin and Wei-Wei Hsiang
Department of Physics, Fu Jen Catholic University, Taipei, Taiwan, R.O.C.

Abstract

In order to avoid the nonlinear chirp due to the self-phase modulation in the amplification process, we set up an Yb-doped double-cladding fiber chirped-pulse amplifier (Yb FCPA). In the experiment, we setup grating pair as compressor to do the best compensation in second order dispersion(SOD). Due to strong nonlinear induced by fibers and third order dispersion(TOD) of Chirped Fiber Bragg Grating stretcher, We can't easily obtain sub-fs pulse in CPA system.While the use of a semiconductor laser as the pump increase power. With pulse picker to reduce the pulse repetition rate from 40.5 MHz to 316 kHz, pulse energy from few nJ enhance to μJ. Amplified pulse's duration with compression and characterization can be maintained around 560fs. The characterization of maintaining polarization pulse and the amplified pulse's duration compression in ongoing.

Experimental setups and results



- **Oscillator:**
  We home-build an ultrashort Yb-doped fiber laser based on the polarization additive-pulse mode-locking (P-APM) method to obtain the fs pulses. The self-starting mode-locked Yb-fiber laser can generate sub-100fs pulses.

- **First-stage amplifier:**
  The CFBG (Chirped Fiber Bragg Grating) is used as a pulse stretcher to avoid the pulse distortion introduced by the SPM(self-phase modulation) and Raman effects. We adjust the polarization by FPC (Fiber Polarization Controller) to reduce the birefringence filter effect due to the non-PM fibers in the second-stage amplifier.

- **Second-stage amplifier:**
  The reduction of the pulse repetition rate is achieved by passing the output from the first-stage amplifier through the AOM. The non-diffracted zero-order output of the AOM is used as the clock signals for dividing the pulse repetition rate, and the pulse repetition rate is reduced from 40.5 MHz to 316 kHz. The pulses with a 316 kHz repetition rate, i.e, the first-order diffraction of the AOM, are coupled into the second-stage Yb-doped fiber amplifier. Besides, we use the Faraday mirror to remove the birefringence filter effect due to the non-PM fibers in the second-stage amplifier.

- **Third-stage amplifier:**
  The output of the second-stage amplifier output is coupled into large-core PM double-cladding Yb-doped fiber to boost the pulse energy. In order to obtain the high coupling efficiency, two lenses are used to expand the beam size to match the core size as well as NA of the large-core double-cladding Yb-doped fiber. The third-stage amplifier is backward pumped by a 976 nm laser diode with the maximum pump power of 50 W.

beam profile chart

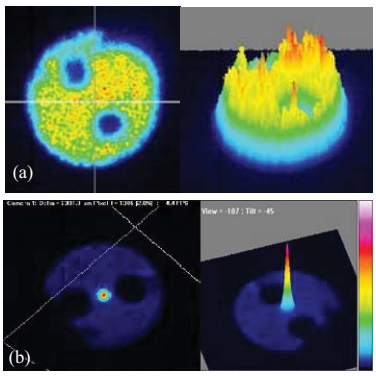


Figure (a) is not coupled into the core of fiber. Figure (b) of the beam profile chart shows the result of the light coupled in the large-core PM Yb-doped double cladding.

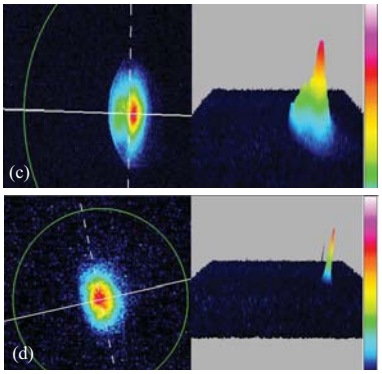
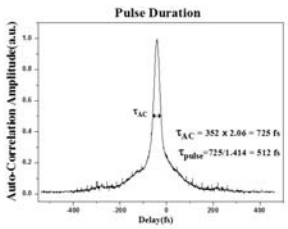


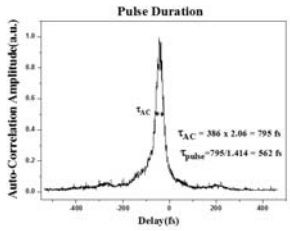
Figure (c) shows the two gratings are not parallel. Figure (d) shows grating pair parallel as compressor which means to do the best compensation in second order dispersion(SOD).

pulse duration (without pulse picker)



- pulse's duration = 512fs
- pulse energy = 83.50 mW/ 40.5MHz = 2.062nJ
- peak power = 2.062nJ / 512fs = 4.027 kW

pulse duration (with pulse picker)



- pulse's duration = 562fs
- pulse energy= 8.1 mW/ 316kHz= 25.6 nJ
- peak power = 25.6nJ / 562fs = 45.55 kW

Conclusions

With our home-made Yb-doped double-cladding fiber chirped-pulse amplifier, we succeed in boosting the pulse energy from few nJ enhance to μJ.
we setup grating pair as compressor to do the best compensation in second order dispersion(SOD). Due to strong nonlinear induced by fibers and third order dispersion(TOD) of Chirped Fiber Bragg Grating stretcher. In our result ,amplified pulse's duration with compression and characterization can be maintained around 560fs. The characterization of maintaining polarization pulse and the amplified pulse's duration compression in ongoing.

References

1. T. Eidam *et al.*, "Femtosecond fiber CPA system emitting 830 W average output power", Opt. Lett. **35** , 94 (2010)
2. A. Galvanauskas, "Mode-scalable fiber-based chirped pulse amplification systems", IEEE J. Sel. Top. Quantum Electron. **7** , 504 (2001)